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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

96300961.8

Der Präsident des Europäischen Patentamts:
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

A.J. Copini

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Sheet 2 of the certificate
Page 2 de l'attestation

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Bezeichnung der Erfindung: Title of the invention: Titre de l'invention:
Negotiation management system and method in an agent-based distributed computing environment

In Anspruch genommene Priorität(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

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The original title of the invention reads as follows :
"Business process provision and enactment".

BUSINESS PROCESS PROVISION AND ENACTMENT

The present invention relates to provisioning of services in a business environment and finds particular application for the management of business process enactment.

Managers in organisations make informed decisions based on a combination of judgement and information from marketing, sales, research, development, manufacturing, finance and legal departments. Ideally, all relevant information should be brought together before judgement is exercised. Requesting pertinent and consistent information across a large company is a complex and time consuming process. Changes to information made in one department can have repercussions throughout a company often invalidating previous decisions.

For these reasons it would be desirable to provide systems and methods which, to some extent at least, manage both the collection of pertinent information and the tasks and resources which use this information.

In accordance with one aspect, the present invention provides a service provisioning system for business process enactment, said system comprising:

an input connected to a distributed computing environment for receiving a service request from an entity;

a response output connected to said distributed computing environment for providing a response to the entity;

processing means to process the service request and provide a response thereto; and

means to access an up-datable data store for storing parameter(s) indicative of the available capacity of the system to provide the service,

wherein the processing means is adapted to process a service request by accessing one or more parameters in the data store, processing the request using the one or more parameters, and producing a response at the output, which response is selected from indications that

a) sufficient capacity is available to provide the service;

b) insufficient capacity is available to provide the service; and

c) sufficient capacity is available to provide the service if modified, together with associated modifications.

It will be understood that the term "entity" as used here means a piece of equipment which can communicate over the distributed computing environment. It will in practice usually comprise at least an input and an output and, often, some means for delivering one or more of the services to be provided. It might be for instance a work station, personal computer or a computing network node.

In embodiments of the invention, the system further comprises a control output connected by said distributed computing environment to one or more tasks and/or resources required to provide the service.

The system may also comprise a data input connected by said distributed computing environment to one or more tasks and/or resources required to provide the service, for receiving data output by the tasks and/or processes, and data processing means to generate said parameters from said data. Alternatively, it may be that the data output by the tasks and/or processes already comprises said parameters.

This system aims to enhance the way a large company runs its business by improving the way it accesses, uses and adds value to its vast quantities of information. The metaphor of 'concurrent engineering' suggests that the best way to achieve a business activity is to bring together as early as possible all the necessary information, resources and skills that are needed to execute that activity.

An advantage of this system is that a decision to provide a service is based on stored parameters and not on real-time or near real-time information of the resources required to provide the service: there is no need to perform a detailed analysis of the resources available to the system before a decision is reached. The system bases its decisions on an estimation of the capacity of the system to provide a service at the requested time.

The stored parameters might include the average time a service is expected to take, the expected cost of performing tasks to provide a service and/or the amount of work already being done by the system. Other information can also be used to determine on what grounds a service will be provided, for example past experience of any dealings with the same entity. Once a system has agreed to provide a service, it can schedule the use of its resources to support the delivery of that service.

Although the lack of a detailed resource analysis during provisioning does increase the risk that once a service has been negotiated for it might not be possible to complete it, such failure can be dealt with acceptably, as described in more detail below.

The processing means is typically adapted to receive data from the resource(s) for use in updating the data store. Such data might comprise a measure of capability of the system on the basis of the past performance of the resources. For example, each time a service has been provided by the system, information about how well the resources performed may be used to adjust the parameter(s). Performance information might include actual cost data and actual time taken to provide a required output. The information might also include task current status information which is readily available to the system.

In some embodiments, the system comprises a request output connected to the distributed computing environment for requesting a component service from another entity. A component service, or sub-service, is one which the system requires in order to provide its service. For example, if the service requested is to open a new business account, a sub-service might be the task of checking the financial viability of the prospective account holder. This sub-service would typically be provided by an entity which could be another system, or maybe even a human operator.

In some embodiments, the system comprises means for scheduling resource(s) to provide a service. Preferably, in this case, the processing means is adapted, in response to a failure by the scheduling means to schedule a resource, in time to complete a service, to: re-schedule the task/service; transmit a message to the entity that the originally requested service can only be provided under different conditions; re-locate the service with another service providing entity; or indicate to the entity that the service cannot be provided. These possible actions give the system flexibility to deal with problems which might arise with the provision of a service.

The above-mentioned steps for recovery can be similarly applied to the case where a service fails during operation. A resource might become unavailable, for example, due to a break in communications.

In general therefore, the system may further comprise means for monitoring for failure, such as of scheduling means. In order to act on detection of a failure, the system may then be adapted to initiate a modified response output in respect of a relevant service request. It may further be adapted to store service requests and to be triggered on detection of failure to identify and access the relevant stored process request, to reprocess it using one or more modified parameters from the updatable data store, and to provide a modified response output.

In embodiments of the invention, the system is arranged to provide more than one instance of a service, and/or of a negotiation for a service, to one or more requesting entities concurrently. An advantage of this aspect is that the system is available for use by plural service requesters. In this respect, preferably, at least some resources as well can support multiple resource requests concurrently.

In accordance with another aspect, the present invention provides a service provisioning system, said system comprising means for negotiating with an entity, in response to a request from said entity, to provide a service and means for accessing one or more resources available for use by the system to provide a service, said negotiating means including data about said system relating to a measure of the current system capacity to provide a service, and being arranged to negotiate substantially on the basis of said data to provide a service in response to a request.

In accordance with a further aspect, the present invention provides a method of business process enactment, said method being implemented in a distributed computing environment including at least one service provider and at least one service requester, said service provider comprising an input to receive a request from the or any service requester within said environment, an output to provide a response to said service requester, processing means to process said request to determine the nature of said response, means to access an up-datable data store for storing parameters indicative of the present capacity of the service provider to provide the service, and a control output to one or more resources in the environment available for use by said service provider, wherein the processing means determines the nature of said response on the basis of the data stored in the data store.

(The terms "service provider" and "service requester" mean here of course equipment for provisioning and accessing services respectively, rather than organisations and the like, as the terms are sometimes used elsewhere.)

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

Figure 1 is a diagram which illustrates a suitable distributed architecture to support an embodiment of the present invention;

Figure 2 is a diagram which shows a basic building block of the architecture of Figure 1;

Figure 3 is a diagram which illustrates the relationships which exist between different parts of the building block of Figure 2;

Figure 4 is a diagram which illustrates the concept of a virtual agency;

Figure 5 is a diagram which represents the constituent parts of an agent according to an embodiment of the present invention;

Figure 6 is a diagram which illustrates an exemplary scenario in which an embodiment of the present invention can operate; and

Figure 7 is a flow diagram of a process for operating a service in the scenario represented in Figure 6.

Figure 1 shows a top-level view of a suitable architecture within a business organisation in which an embodiment of the present invention can operate. In Figure 1, a distributed system of agents 10 are connected to one another via a suitable communications network 11. The environment, including the agents and the communications network, constitutes a distributed processing environment. Each department 12 in the organisation is represented by its own agent 10 in the environment which can provide a service related to the department to other agents.

In this description the term "agent" relates to a function or process which operates in the distributed computing environment and which can act autonomously to receive a request for an operation and provide a result. An agent normally has an up-datable local data store and usually also some global information about the distributed environment in which it sits. Agents operate autonomously, having decision-making functionality (intelligence) allowing them to negotiate and output a result in response to an incoming message.

Typically, an agent is embodied as a piece of software, for example written in the C programming language, running on a suitable computing platform, for example a UNIX (Trademark) based platform. Requests and results are passed between an agent and a requesting entity, which might be another agent, across a suitable communications network, for example a TCP/IP-based local area network, to which the computing platform is interfaced. In some embodiments, plural agents can reside on a common computing platform and, conversely, a single agent can be realised across plural computing platforms in the environment. Also, the computing environment might be heterogeneous, and support various different types of computing platforms.

The agents 10 in Figure 1 are able to communicate and negotiate with each other for the provision of services. Services provided by agents can range from the provision of information and data to the implementation of some concurrent task within a business process. A service comprises a number of primitive tasks. A task, being a primitive functional component of a business process, is a re-usable building block that allows an agent to manage processes which make-up an enterprise. Typically, a task has a low-level structure which allows a user to define the basic operations that make up a business process and can be implemented as a managed object in the distributed computing environment. A task also has an implicit representation of resources it will consume when it is activated and an explicit representation of its operational requirements, including the information it requires and produces, and its duration of activation. Thus, the way a task behaves under normal circumstances, once activated, is predictable. In this embodiment, a task supports two interfaces: a management interface to support a standard set of operations which permit the exchange of management commands and information between tasks and agents; and an operational interface to support a non-standard, but agreed set of operations which allow the exchange of operational messages between tasks. In essence, an agent 10 on the infrastructure in Figure 1 is characterised by the services that it provides.

In this embodiment there are three main requirements of the architecture: autonomy, concurrency and migration. Autonomy means that a local organisation, for example a legal department, is able to define how it will perform its own local

tasks and processes. The definition will determine how an agent representing the local organisation will interact with other agents. Tasks and services associated with agents should be able to run concurrently, with interactions between the tasks and services being monitored and managed by the agent. Migration allows services to be defined for agents incrementally, without the need to redesign the overall distributed system.

Figure 2 shows a representation of a basic building block 20 of the architecture. The basic building block comprises an agent 21 and tasks 22 which are under the control of the agent. In some embodiments, building blocks 20 may be arranged to operate on a peer-to-peer basis. That is, each unit 20 is able to negotiate with any other unit when supplying or requesting a service. Most commercial environments are founded on organisational models which are logically divided into a collection of related resources and services. Thus, in the present embodiment, the architecture draws upon this principle to group services and tasks where it makes pragmatic sense. For the present purposes, such a grouping of tasks and services is known collectively as an agency.

An agency is a collection of tasks (and by implication resources) and (sub-)agents that are under the direct control of an agent. An agency reflects the hierarchical grouping of tasks that are under some form of common ownership, and for which there is some reason to attempt to optimise the use of resources in the execution of those tasks. The collection of tasks and (sub-)agents in an agency does not necessarily reflect a functional grouping (though in most organisations this effect may be expected).

In Figure 3, other servant agents 32 and 33 can also belong within the agency of a controlling agent 31. This means that servant agents 31 and 32 provide services exclusively to the controlling agent 31. However, a servant agent still maintains its autonomy. A servant agent cannot offer its service directly in the world outside its agency. Under some conditions an agent can have both the role of a controlling agent and of a servant agent. Agents in an agency will normally be the controlling agents of lower level agencies. This leads to a hierarchical organisation of agencies reflecting the logical structure.

Generally, there are two types of agent interaction: negotiation and service management. In practice it is possible to have a spectrum of interactions between these extremes.

In the present embodiment, a number of separate services can be combined in providing a single service. The agent providing the service is designated the controlling agent, and then a set of (sub-)services from different agents can be selected and grouped to form a virtual agency, as illustrated in Figure 4.

A virtual agency is a structure which supports the service management function of an agent. As shown in Figure 4, a virtual agency 40 is the collection of tasks and sub-services 41 and 42 (from other agents 43 and 44) involved in the provision of some service by a controlling agent 45. In this case, the controlling agent 45 will have (or require) contracts for the (sub-)services that it requires from the other agents 43 and 44. The tasks 46 under its direct control that are involved in the provision of the service will be a sub-set of its agency. Each virtual agency is in a one-to-one mapping with a service that an agent provides. Before providing a service, the agent 45 can assemble pro-actively (at least some part of) its virtual agency by negotiating with other agents for its required (sub-)services.

An important advantage of supporting virtual agencies is that services can be provisioned automatically in real-time: resources can, in effect, be pooled from anywhere. An agent can provide multiple services, each one demanding a virtual agency to be assembled and controlled. For this reason, it is necessary that the platforms supporting agents therefore can support multiple threads. Operating systems which support multiple threads are OS2, UNIX, Windows 95 (Trademark) or Windows NT (Trademark). In practice, distributed computing platforms have been developed specifically for supporting multi-threaded applications. One such platform is DAIS from ICL, which is conformant with the Object Management Group's (OMG) Common Object Request Broker Architecture (CORBA). CORBA-compliant products offer the Interface Definition Language (IDL) as a homogeneous object interface. An advantage of adhering to the CORBA standard is that all COBRA version 2 compliant platforms will be able to inter-work with each other extending the potential scope of applications using them.

In accordance with the present embodiment, an agent basically has three functional external interfaces: an agent negotiation interface having a standard set of primitives to support the negotiation of terms between agents requesting a service (client agents) and agents supplying services (server agents); a service management interface having a standard set of operations which permit the exchange of information between client agents and server agents; and a task management interface having a standard set of operations which permit the exchange of management commands and information between agents and tasks. In practice, all three functional interfaces are realised as a single physical interface, for example an interface in a computer system, in connection with a communications network.

Figure 5 shows the high-level, functional modules of an agent according to the present embodiment. The modules can reside on one computing platform or on several. Each module is typically a software process, where all the modules together define the character of the agent. Communications between modules is effected either by parameter passing in procedure calls, by each module having access to common data files containing relevant, up-datable data, or by inter-object messaging.

The agent 50 includes a negotiation management module (NMM) 51. The NMM 51 is invoked when it is necessary that a contract should be established with some external agent for providing a particular service. An agent can commit to a contract without performing detailed resource allocation. That is to say, the NMM 51 of an agent can commit that agent (a server) to provide a service without detailed scheduling by the agent's resource management module (RMM), which is described in more detail below. In this way, an agent de-couples negotiation from detailed resource scheduling, in order to support real-time performance during the negotiation process. In the present embodiment, an agent can negotiate for multiple contracts simultaneously. The NMM 51 of an agent is necessarily multi-threaded for this purpose.

During negotiation, the NMM 51 correlates and balances multiple criteria both within negotiation for a single service and across all the negotiations in which the agent in involved. The criteria can be modelled as (partial) ordinal value spaces that represent parameters such as quality, time, cost, etc.

A negotiation language, an example of which is illustrated in more detail below, is supported by the NMM 51 to support agent negotiations. The language comprises agreed primitives and a protocol to allow agents to suggest modifications to, and consent to, the value of parameters in a contract. The negotiation language protocol defines the valid ordering on sending and receipt of primitives during negotiation between agents. Negotiation for the contract involves the selection of messages referring to former messages, stored in a data storage area, conforming to a protocol and processing incoming messages with regard to the protocol.

A contract, within the meaning of this description, is the result of a negotiated agreement between agents. The contract contains the terms and conditions for the delivery of an instance of a service. The contract contains a list of agreed values for parameters which establish the criteria for the delivery of the service. For example, the time(s) at which the service will be available and/or activated, the duration of the activation, the quality, the cost, penalty for failure, etc. These parameters are contained in a contract template, defined for each service on offer, which is used by an agent to structure its negotiations.

A RMM 52 serves as a link and balancer between an agent's two primary roles - that of being an individual and that of being part of a community. The RMM 52 manages resources controlled by the agent. The major concern of the RMM 52 is scheduling. This is essentially the maintenance of negotiated contracts. This involves the co-ordination and scheduling of services and tasks to ensure that existing contractual obligations are met. The RMM 52 checks regularly the conditions regarding an internal time line and changes of information. The RMM 52 also triggers negotiation by the NMM 51 when a contract is required.

A service/task management module (SMM) 53 is responsible for launching and controlling services and tasks. The SMM 53 deals with contracts which have been established, ensuring that terms and conditions are honoured, that appropriate levels of reporting take place and that the contract is finished cleanly. The SMM 53 also maintains the status of active services. This involves the maintenance of stacks, to perform the successive decomposition of services, and pointers to the active sub-services and tasks. Moreover, the SMM 53 is responsible for the provision of required information in order to launch a service

including the checking of conditions and returning produced results. The SMM 53 furthermore performs tasks and task error tracking.

An agent can execute multiple services and tasks simultaneously. The SMM 53 of an agent needs to be multi-threaded for this purpose. During operation, the SMM 53 is also responsible for handling exceptions from the tasks within its agency and from other agents (as servers). Exceptions can be resolved, in accordance with the present embodiment, in one of several ways: re-resourcing the task/service by the RMM 51; re-negotiating the terms of the contract (as the defaulting server agent); re-locating the service with another agent (as the aggrieved client agent); or ignoring the exception and accepting a penalty (if appropriate). This flexible approach to resolving exceptions is also applied to instances where a contract has been entered into, without detailed resource scheduling, but cannot be completed due to an unforeseen demand for a particular resource or agent (as a server).

Each agent 50 has an information store, for example in main memory or on an external data storage device, which provides both persistent and temporary (working) memory. The store can be partitioned into the self and acquaintance models.

The self model (SM) 54 comprises information on the services provided by the agent 50. The SM 54 maintains the representation of services and information under the regime of an agent and stores the contracts to which an agent (as a supplier of a service) is committed.

The acquaintance model (AM) 55 enables the agent 50 to build up a picture of information as to the services offered by other agents and a history of the performance of those agents. Such historic information can determine which solution to a problem an agent adopts, in the event there is a choice. The AM 55 stores also the contracts that an agent (as a recipient of a service) made with other agents.

There are two support modules which support the creation and communication of the agent 50. A communication module (CM) 56 is the focal point for both in-coming and out-going messages. The CM 56 supports the distribution of software agents across the distributed computing environment.

An initialisation module (IM) 57 is the module that is started first. This module initialises all the other agent modules. Once all the modules are in place, the IM 57 is mostly inactive. It exports an object identifier to the distributed computing environment so that it can be located by other agents. The IM 57 is also the initial point of connection between the agent and a range of agent management, inspection and debugging tools.

Figure 6 illustrates an example of a virtual agency according to the present embodiment. There are six parties in the agency, each having a respective agent: a sales department 600 and its associated agent 60; a customer service division 610 and its associated agent 61; a legal department 640 and it associated agent 64; a design division 630 and it associated agent 63; a surveyor department 650 and its associated agent 65; and a customer vetting department 620 and its associated agent 62.

The customer service division 610 is able to provide, via its agent 61, a "provide customer quote" service. This service has three component services: a "legal advice" service; a "vet customer" service; and a "cost and design customers network" service, plus five component tasks: "capture customer details" 612; "capture customer requirements" 611; "identify service requirements profile" 614; "identify service" 613; and "provide quote" 615.

The legal advice service is offered as a "regular" service (the types of service offered are explained in more detail below) by the legal advice agent 64, whereby on a regular basis the legal department will review the customer requests for bespoke services and flag those that are not legal or which pose legal problems.

The vet customer service, provided by the vet customer agent 62, is an "on-demand" service consisting of a single task 621 which vets customers by verifying identity and checking credit worthiness. Typically, the vet customer service would be provided by an out-sourced credit checking agency.

The cost and design customer network service, provided by the cost and design customer network agent 63, costs the bespoke service requested by the customer. This service comprises three tasks and one component service. The tasks are: "analyse requirements" 632; "design network" 631; and "provide quote" 633. These tasks, based on their knowledge of the customer's premises

equipment (CPE), provide a quote for the required network. In certain circumstances, the survey customer site service might be utilised to survey the customer's site.

The survey customer site service, provided by the survey customer site agent 65, is a "one-off" service which has to be specifically negotiated for when needed. This service is only required when there are insufficient details on a customer's site for design to commence. The process for providing a quote is exemplified in Figure 7.

The provide customer quote service is typically offered to a telecommunications sales department 600 to support its customer servicing. On receipt of a customer service quote request, the customer service agent 61 will generate a quote for the required service and send it to the customer.

The process is initiated with a customer contacting the customer service division in step 700. The customer details are captured, in step 705, and whilst the customer is being vetted in step 715 the customer's requirements are captured in step 710. If the customer's vetting fails, then the process is terminated by step 720.

The customer's requirements are recorded and mapped against the service portfolio in step 725. If the requirements can be met by a standard off-the-shelf portfolio item then an immediate quote can be offered in steps 730, 735 and 740, after which the service ends. In cases of bespoke service requests, the process is more complex and involves a bid manager.

For bespoke items the bid manager(not shown) further analyses the customer's requirements in step 745, and the legality of the requirements are checked in step 750. In circumstances where a request is possibly illegal the quote process will be suspended pending more information from the customer at step 770. Where a request is definitely illegal, determined by step 760, the process is terminated and the customer informed. For the present purposes, it will be assumed that the bid manager is a human operator, but it is envisaged that a number of the tasks can be automated.

In order to prepare a network design and a quotation it is necessary to have a detailed plan of existing equipment at the customer's premises. In certain cases plans of the CPE might not exist or be out of date. In such cases the bid

manager will determine whether the customer site should be surveyed in step 755. This would typically only be done where the bid value exceeds a certain level (ie the most profitable bids). If required a survey is requested in step 765. Once the required information on customer CPE is available the network is designed in step 775. On completion of the network design and associated costing, the customer will be informed of the service quote in step 740 and the process terminated.

Each activity in this process requires resourcing and has a start and an end point whereby progress can be measured. The choice points in the process indicate which activities require provisioning to operate sequentially. Similarly, there are a number of activities which must/may operate concurrently and which require co-ordinating.

The key role of an agent is to provide a service. A service can be requested (or negotiated for) by another agent, and typically this may result in the transfer of information between the agents. Agents must contain the definitions of how to provide each of the services which it offers. Accordingly, a description for each service is represented in the agent. A service description is made up of two types of primitives:

1. tasks - executed entirely within the control of the agent;
2. services - provided by other agents over the infrastructure.

Tasks and services may be initiated concurrently, and the interaction and communication between them is managed automatically by constraints in the service description. It should be noted that services in turn may be defined recursively in terms of services from other agents, but eventually the definitions will be solely in terms of task.

A service is a packaging of tasks and other (sub-)services that allows an agent to offer (as server) from its agency, or to receive (as client) from another agent, some functional operation. The service can be re-used as a component of another service. In the present embodiment, a service is a recursive control structure composed of tasks, other (sub-)services and performance parameters. The performance parameters are agreed during a negotiation process between two

agents (referred to as client and server respectively). These parameters determine the precise characteristics of an instance of a service upon activation.

In some situations, an agent may need to guarantee the existence and availability of a particular service with some fundamental level of assurance and reliability. This would be defined by the performance parameters. There are three basic levels of service: one-off, which allows a single activation of the service (the time of activation is agreed during negotiation); regular, which allows multiple activations of the service at agreed and pre-scheduled times; and on-demand, which allows activation of the service at and time within an agreed time window.

A service description is created and registered with an agent by a language which supports the formulation of complex concurrent operations. A description comprises a list of statements defining the steps which together define the service. Within the language, each statement expresses both the sub-set of a virtual agency which is to be used and the condition(s) under which control may pass to the next statement. The language also contains primitives to express that tasks or (sub-)services may be executed concurrently, or that they must be run concurrently. In some cases, however, sequential operation is also provided for.

Preferably, the service description language is an interpreted language, and services may therefore be re-defined by a service creator and registered with an agent without extensive re-compilation. For this reason, each of the core modules in an agent includes an interpreter to support the main function of the module (service negotiation, resource management and service/task execution respectively). The language generally combines aspects of declarative non-determinism, which allows an agent to determine dynamically which elements of the virtual agency to employ, and direct procedural control, which allows the service creator to structure and order the language statements.

In use, an agent uses a service description to determine, firstly, how best to negotiate for sub-services in its virtual agency and, secondly, how to manage the execution of those sub-services together with its own tasks (if it has any).

A service can be defined, for example, by the following features:

1. Each service has a unique name.

2. Each service has a guard. A guard declares information which is required in order to launch the service. There may also be constraints

expressed such as that a service may be launched only when some value x is available and is greater than 5, etc.

3. Each service may have assumptions. An assumption may impose further constraints on information or assign default values (which are then believed but perhaps not yet known).

4. Each service has a body which describes how the service can be executed.

By way of example, the part of an agent's self-model which contains the service descriptions may be instantiated in the following manner:

```
(Service
    :Name PriceForecast
    :Guard (Region, ProductionCapacity, CapacityCompetition, Demand,
            Experience)
    :Assumption (SalesLevel :Default 100 :Obtain)
    :Body (Sequence
            (Parallel
                (Sequence CreateTable, SetYears (94..96))
                (Calculate  (Region, ProductionCapacity,
                            CapacityCompetition, Demand,
                            Experience))
            StoreInTable))
```

This routine states that a price forecast is produced based on information about a region, the production capacity of the company and the capacity of the competition, the demand specified by a client and the experience of a company which is fixed in the services guard. In general, this information will not be available automatically and has to be provided on demand. This will be done by looking up an agent's self and acquaintance models. Most of the information which is not given beforehand might be obtained via launching appropriate services as indicated by a "provided-by" slot. After checking this initial condition (guard), in order to execute the appropriate calculations, the agent will assume that the sales level (in relation to the specified demand) will be 100%. Albeit in order to

justify its calculation, the agent will have to launch a service to obtain the definite value of the sales level. When this has been checked, the agent will initiate the service execution, ie it will launch the body.

It should be noted that none of the services in the body needs to be executed by the agent itself. It is likely that the parallel part of the body will be provided by different agents. In general, each of the services in the body will be represented somewhere in the agent's self or acquaintance models. In fact, what the body describes is that a price forecast is provided as a short sequence of services. The first service is a parallel service which is followed by the service "StoreInTable". The parallel service describes the creation of a table in which the years 94 to 96 are initialised. At the same time (in parallel), an agent performs some calculation. When this has been provided successfully, then the results may be stored in the table.

There is a need to define a language that enables the agent to communicate and negotiate. Furthermore, when two or more agents are communicating they must share a common view of the problem domain. The following description provides an example of such a language for negotiation between two peer-level agents each representing their own respective agencies. It will be appreciated, however, that other forms of language would be equally as suitable for this purpose. The generic service/information negotiation structure is as follows.

1. Find/locate (a service or piece of information) - make contact.
2. Ask/explain (what is the form or nature of the service or information) - get the details.
3. Establish/negotiate (setting a service or receiving some information) - agree what is to be done.
4. Execute/review/inform (perform the service or deliver the information, with the ability to review progress and inform when necessary) - do what you agreed.
5. Terminate.

It is important that this structure applies to both explicit service requests as well as the more general, implicit service requirement of finding, locating and managing information within a business. The structure employs the following primitives, numbered in accordance with the above structure.

1. CAN (YOU/ANYONE) DO <a service s>
   CAN (YOU/ANYONE) PROVIDE <information i>
   -->>return list of service/information providers

The primitives would be equally applicable in a multi-cast situation involving department or enterprise based agents and location brokers, as well as a contract net type of broadcast request for the service. Various degrees of sophistication could be imagined in terms of the details associated with the location of the service provider dependant upon the type of models that are developed for agents themselves. These primitives can be summarised as saying "WHO" can do this and "WHERE" they are.

2. SERVICE DETAILS <ask agent a, regarding service s>
   INFORMATION DETAILS <ask agent a, regarding information i>
   -->>return list of <inputs required>, <outputs given>,
   <Optional Resource ("time"/"cost"/"..." estimate>

These primitives let you establish exactly what the service consists of in more detail. It can be summarised as saying "WHAT" can be done. As no global common language is assumed, an essential additional primitive here will be "EXPLAIN <ontology/term>" which will be needed to allow agents to handle new terms.

3. PROPOSE <agent a, service s, conditions c, optional rationale r>
   COUNTER PROPOSE <agent a, service s, conditions c, optional rationale r>
   REJECT

ACCEPT

--> >return <agreement (working conventions, reporting level, penalties, etc)>

These are the basic primitives that allow agents to agree how a service is to be provided. The conditions will be split into "mandatory" and "desirable". The optional rationale and details of service provision should provide agents with the mechanism to break deadlocks arising from "unnecessary" mandatory requirements, or provide novel/alternative forms of service provision. This should allow much more sophisticated forms of negotiation processes to be developed/researched. The key thing to note here is that excepting a proposal, after any modifications (and perhaps nested asking/explanation), results in a specific contract that can then be scheduled to be carried out.

4. INVOKE <agent a, service s, agreement c>
INFORM (ie notify) <agent a, mode of acknowledgement m>
QUERY/INSPECT <service s>
REVIEW <services delivered d>

Services are invoked with respect to some prior agreement, after which the progress can be queried or formally reviewed according to the reporting levels in the contract. If it is necessary for the agents to inform each other of events (unforeseen or otherwise) then this can be done with the mode of acknowledgement set to "none" or "need acknowledgement" or "re-negotiate". This is a critical primitive that will allow the whole negotiation process to be become nested if necessary.

5. TERMINATE <status s, option reason r>

When a service terminates it will either have satisfied its "success" or "delivery" criteria set out in the contractor not. If not, an optional reason should be given for termination.

The above description illustrates an embodiment of the present invention suitable for managing business process enactment. The embodiment demonstrates how multiple agents in a distributed computing environment can co-operate to manage both the collection of pertinent information and the tasks and resources which use the information. Such a system potentially speeds up decision making within an organisation to provide a better overall service to its internal and external customers.

3

CLAIMS

1. A service provisioning system for business process enactment, said system comprising:

an input connected to a distributed computing environment for receiving a service request from an entity;

a response output connected to said distributed computing environment for providing a response to the entity;

processing means to process the service request and provide a response thereto; and

means to access an up-datable data store for storing parameter(s) indicative of the available capacity of the system to provide the service,

wherein the processing means is adapted to decide, substantially on the basis of data held in the data store, whether to provide a service, to propose conditions under which the system is willing to provide a service or to decline to provide a service.

2. A system according to claim 1, wherein the way in which the processing means is adapted to make a decision is that the processing means is adapted to process a service request by accessing one or more parameters in the data store, processing the request using the one or more parameters, and producing a response at the output, which response is selected from indications that

a) sufficient capacity is available to provide the service;

b) insufficient capacity is available to provide the service; and

c) sufficient capacity is available to provide the service if modified, together with associated modifications.

3. A system according to either one of the preceding claims, comprising a control output connected by said distributed computing environment to one or more tasks and/or resources required to provide the service.

4. A system according to claim 3, wherein the processing means is adapted to receive data from the tasks and/or resource(s) for use in updating the data store.

5. A system according to claim 4, wherein said data includes task/resource performance and/or task/resource status data.

6. A system according to any one of the preceding claims, comprising a request output connected to said distributed computing environment for requesting a component service from another entity.

7. A system according to any one of claims 3 to 6, comprising means for scheduling tasks/resources to provide a service.

8. A system according to either claim 6 or claim 7, comprising means for scheduling a component service to provide a requested service.

9. A system according to claim 7 or claim 8, wherein the processing means is adapted, in response to a failure by a scheduling means to schedule a task/resource or component service, to: re-schedule the task/resource/component service; transmit a message to the entity that the originally requested service can only be provided under different conditions; re-locate the service with another service providing entity; or indicate to the entity that the service cannot be provided.

10. A system according to any of claims 7 to 9, wherein the processing means is adapted, in response to the inability of a resource or component service to be completed successfully, to: re-schedule the task/service; transmit a message to the entity that the originally requested service can only be provided under different conditions; re-locate the service with another service providing entity; or indicate to the entity that the service cannot be provided.

11. A service provisioning system, said system comprising means for negotiating with another entity, in response to a request from said other entity, to provide a service and means for accessing one or more resources available for use by the system to provide a service, said negotiating means including data about said system relating to a measure of the current system capacity to provide a service, and being arranged to negotiate substantially on the basis of said data to provide a service in response to a request.

12. A system according to claim 11, comprising means to update said information on the basis of the past performance of the system.

13. A system according to either claim 11 or claim 12, comprising means to schedule resource(s) for use by the system necessary to provide a service.

14. A system according to claim 13, comprising means to initiate the negotiating means to re-open negotiation with the entity which requested the service in the event one or more resources cannot be scheduled.

15. A system according to any one of the preceding claims, arranged to provide more than one instance of a service, and/or of a negotiation for a service, to one or more requesting entities concurrently.

16. A distributed computing environment comprising plural systems according to any one of the preceding claims connected by a communications network, wherein at least one of said systems is arranged to provide more than one instance of a service, or of a negotiation for a service, to one or more requesting systems concurrently.

17. A method of business process enactment, said method being implemented in a distributed computing environment including at least one service provider and at least one service requester, said service provider comprising an input to receive a request from the or any service requester within said environment, an output to provide a response to said service requester, processing means to process said

request to determine the nature of said response, means to access an up-datable data store for storing parameters indicative of the present capacity of the service provider to provide the service, and a control output to one or more resources in the environment available for use by said service provider, wherein the processing means determines the nature of said response on the basis of the data stored in the data store.

18. A method according to claim 17, wherein, in the event a service provider and a service requester agree a contract to provide and accept a service respectively, a copy of the contract is stored as a data structure representing the terms and conditions of the contract by both the service provider and the service requester.

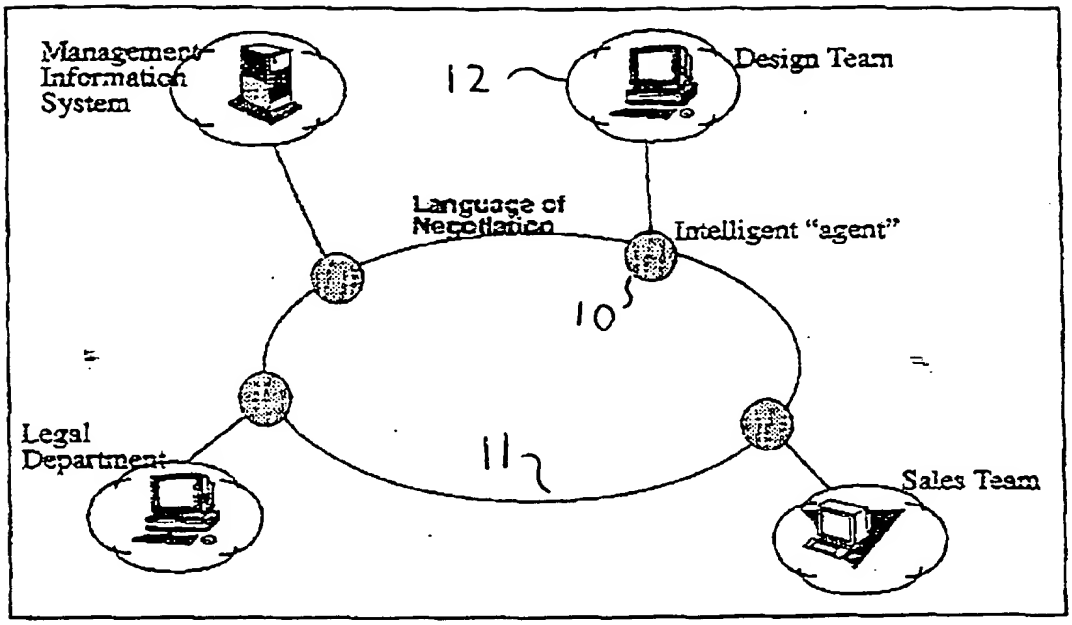


Fig. 1

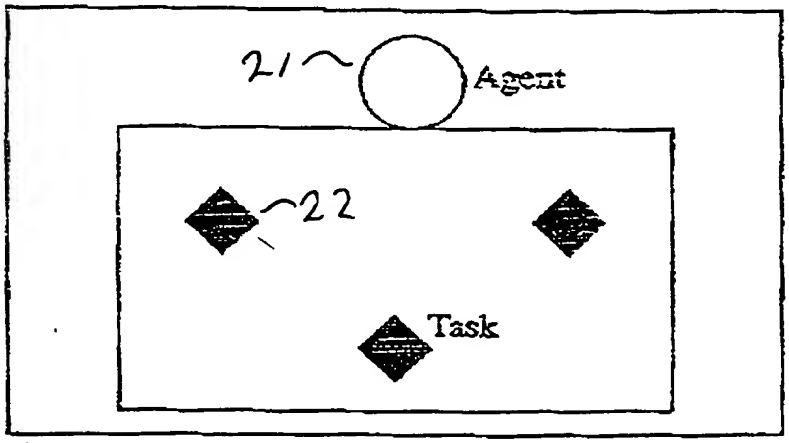


Fig. 2

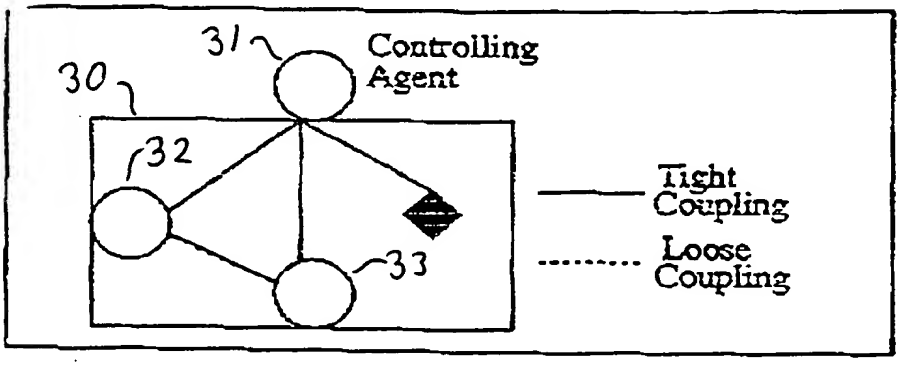


Fig. 3

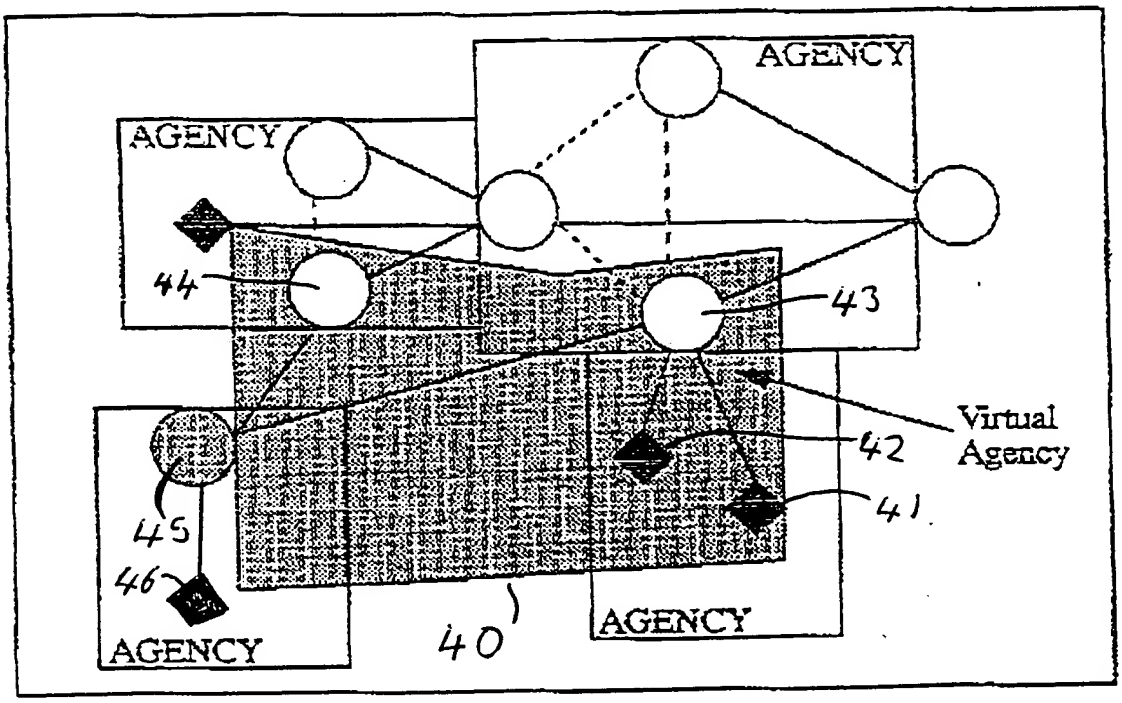

AGENCY
AGENCY
44
43
Virtual Agency
42
41
45
46
AGENCY
AGENCY
40

Fig.4

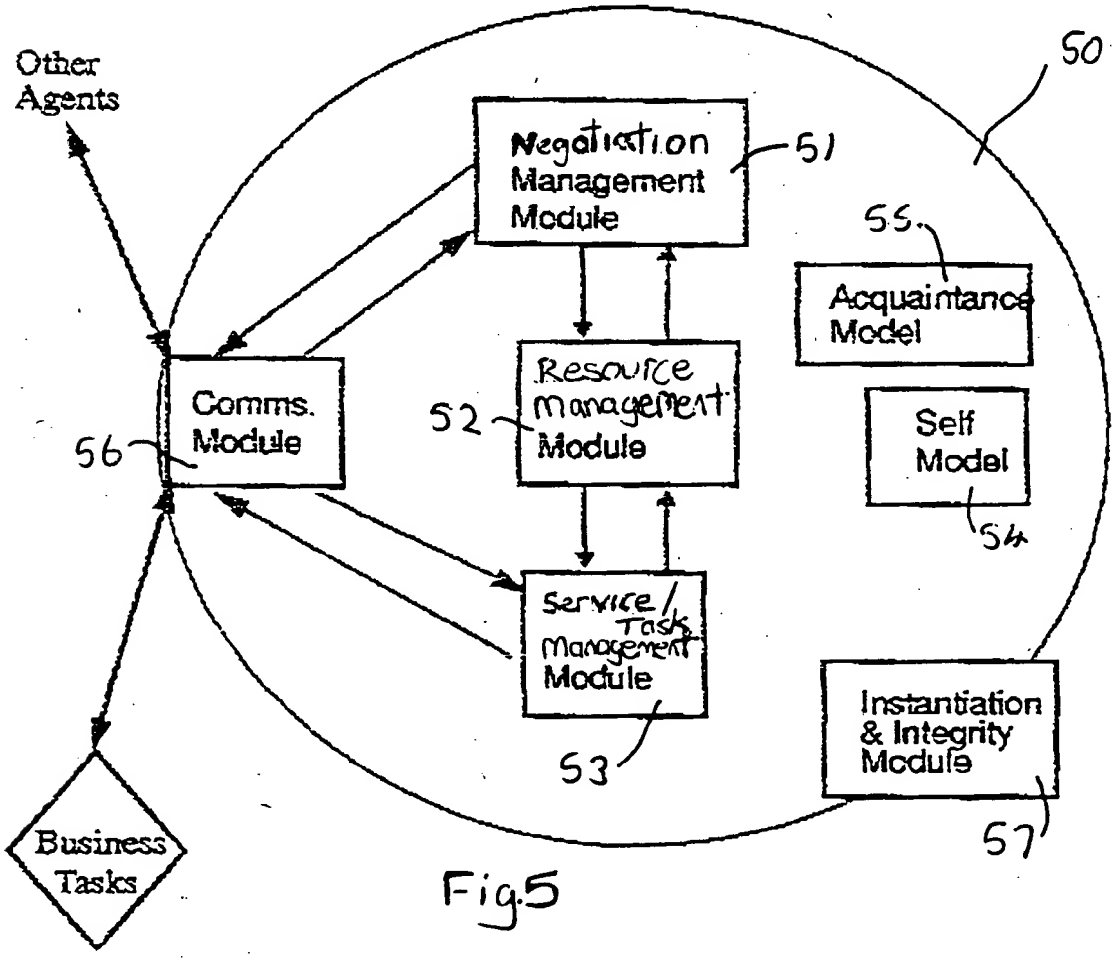
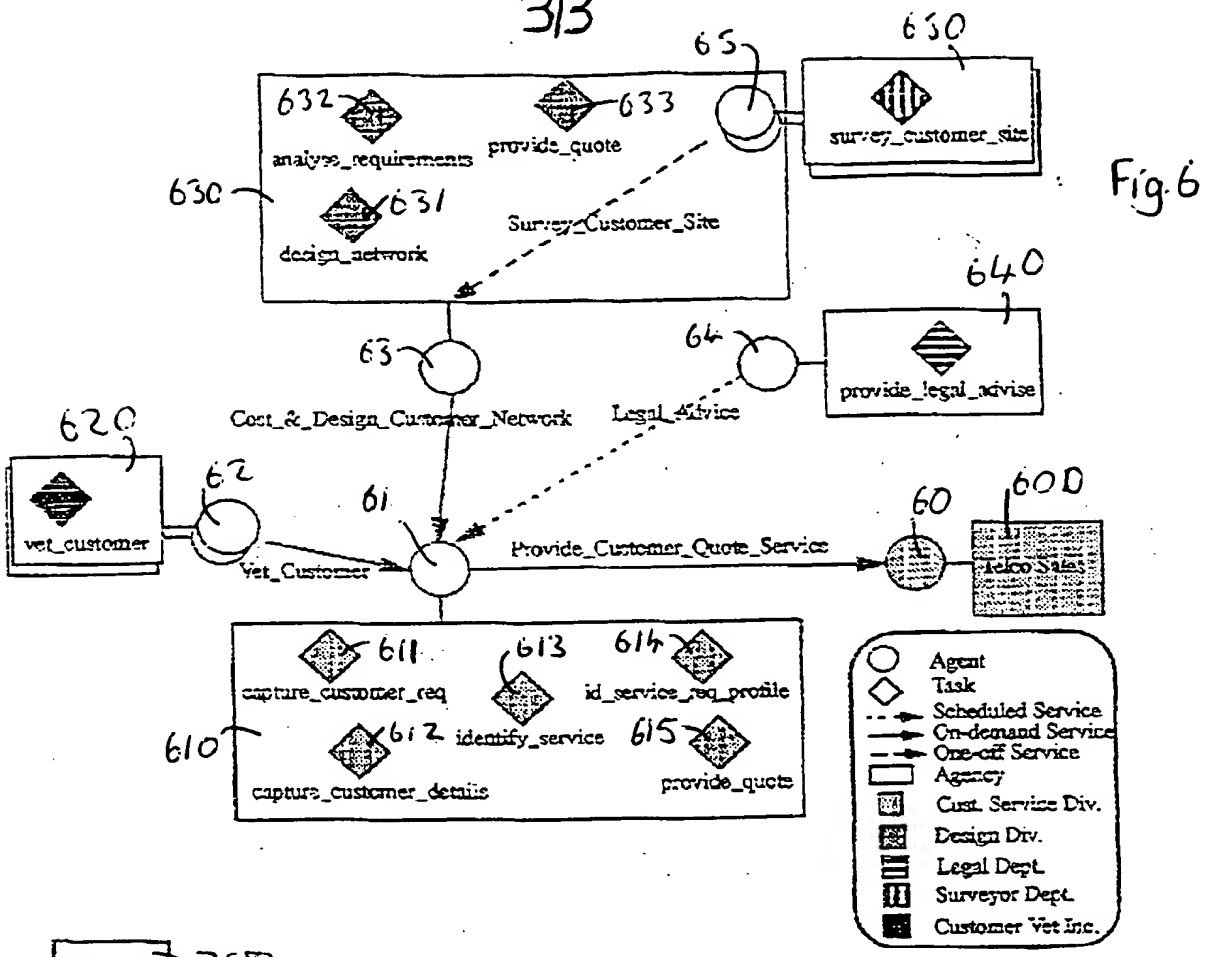

Other Agents
50
Negotiation Management Module
51
55
Acquaintance Model
Resource Management Module
52
Comms. Module
56
Self Model
54
Service / Task Management Module
53
Instantiation & Integrity Module
57
Business Tasks

Fig.5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633
provide_quote
survey_customer_site
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631
design_network
Survey_Customer_Site
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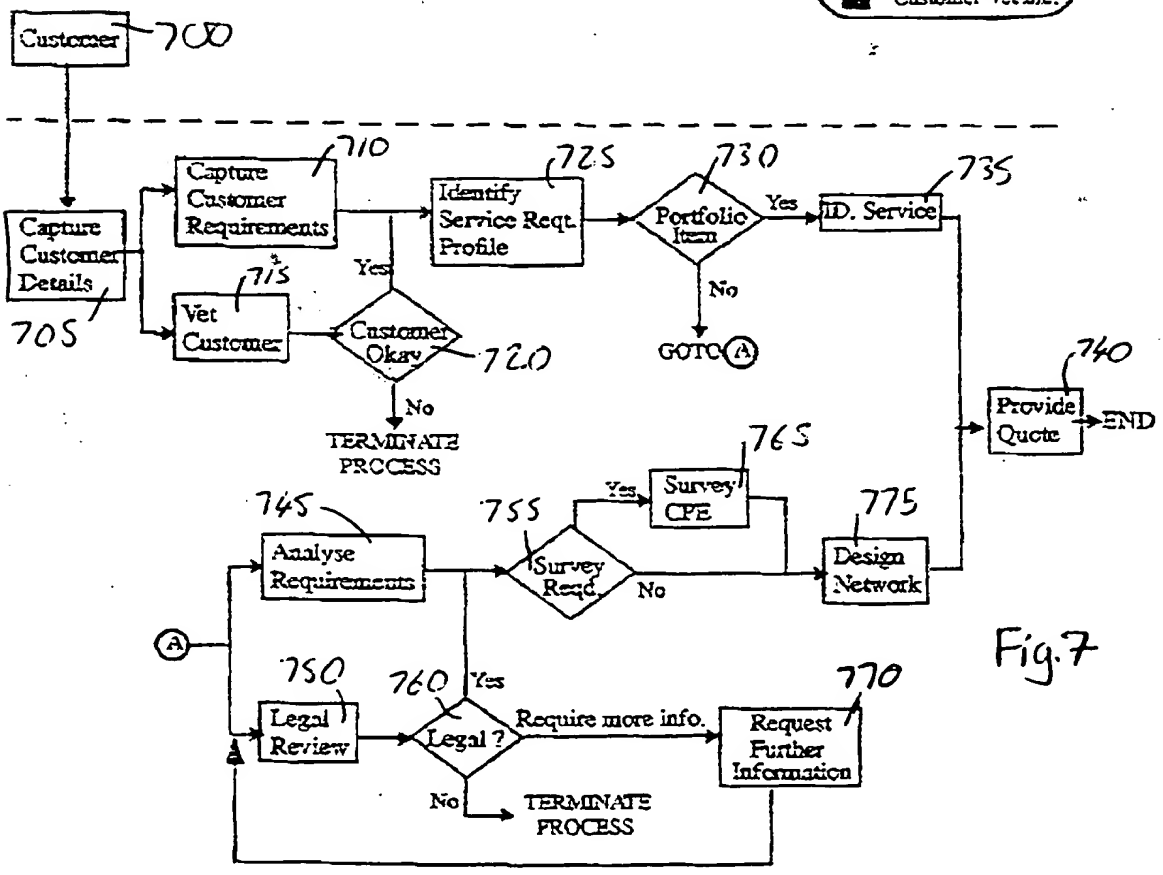
Cost_&_Design_Customer_Network
Legal_Advice
620
vet_customer
62
61
60
600
Vet_Customer
Provide_Customer_Quote_Service
Telco Sales
611
613
614
capture_customer_req
id_service_req_profile
610
612
identify_service
615
capture_customer_details
provide_quote
Agent
Task
Scheduled Service
On-demand Service
One-off Service
Agency
Cust. Service Div.
Design Div.
Legal Dept.
Surveyor Dept.
Customer Vet Inc.

Fig.6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Capture Customer Details
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Capture Customer Requirements
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Vet Customer
Yes
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Customer Okay
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TERMINATE PROCESS
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Identify Service Reqt. Profile
730
Portfolio Item
Yes
No
GOTO A
735
ID. Service
740
Provide Quote
END
745
Analyse Requirements
755
Survey Reqd.
Yes
765
Survey CPE
No
775
Design Network
A
750
Legal Review
760
Legal ?
Yes
Require more info.
770
Request Further Information
No
TERMINATE PROCESS

Fig.7